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Technical Report No. 3

SHIPBOARD OBSERVATION OF ELECTRONICS PERSONNEL:  
IMPLICATIONS FOR THE TRAINING OF ELECTRONICS PERSONNEL.

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PREFACE

This report is one of a series based on shipboard observation of electronics personnel aboard ships of the destroyer class. The titles of these reports are given here along with a brief indication of the content of each. Security restrictions do not permit the general circulation of all of these reports but the accompanying list will help the reader place the present report in context.

1. Shipboard Observation of Electronics Personnel:  
A Description of the Research.

A general presentation of the problem, its background, and the observational techniques which were employed.

2. Shipboard Observation of Electronics Personnel:  
Detailed Descriptions of Observational Techniques.

A report for the professional worker who desires precise detail regarding the forms and instructions used and the decisions underlying their selection. The summarized data are provided in a classified supplement.

3. Shipboard Observation of Electronics Personnel:  
Implications for the Training of Electronics Personnel.

Various problems of training are formulated and related to the observational data. (RESTRICTED)

4. Shipboard Observation of Electronics Personnel:  
Shipboard Activities of Electronics Technicians.

Detailed accounts of the activities of electronics technicians are presented. Topics such as the materials, duties, problems, and future plans of the technicians are discussed. (RESTRICTED)

5. Shipboard Observation of Electronics Personnel:  
Brief Descriptions of Related Electronics Jobs.

The jobs of the Sonarman, Radarman, and Radioman are briefly described. The areas of overlap between these jobs and the job of the ET are discussed. (RESTRICTED)

6. Shipboard Observation of Electronics Personnel:  
Implications for Certain Operational and Administrative Problems.

Problems of shipboard administration, policy, and the operational requirements of the electronics situation are related to the observational data. (RESTRICTED)

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7. Shipboard Observation of Electronics Personnel:  
General Conclusions and Recommendations for Further Research.

The objectives of the research are reexamined and general conclusions are drawn. Promising research hypotheses and methods are presented. (RESTRICTED)

ACKNOWLEDGEMENTS

The research reported in this series reflects the contribution of a large number of persons within the Military Establishment. Grateful appreciation for this assistance is extended to the Cruiser Destroyer Force, Pacific; the Training Command, Pacific, and the Underway Training Element of that command; the Training Division and the Research Division, Bureau of Naval Personnel; the Personnel and Training Branch of the Psychological Services Division of the Office of Naval Research; and the Electronics Coordinator's Section of the Office of the Chief of Naval Operations.

ABSTRACT

The data obtained in the course of an extensive series of observations aboard ships of the destroyer class are examined from the standpoint of the technical training of electronics personnel within the Navy.

Descriptions of the kinds and amounts of training in electronics maintenance that occur on shipboard are presented and several of the problems attendant to such training are discussed.

The judgments of the electronics technicians regarding the relevance of a number of curriculum topics to their jobs are presented and discussed.

Evidences of specialization and the effects of it are given in the fifth section of the report. The pros and cons of various types of specialization are discussed.

Attitudinal problems and other non-technical aspects of the ET's training are briefly discussed in Section VI.

The level of training in electronics that had been received by enlisted members of the sample group are given in Section VIII for the purpose of indicating the level at which current electronics maintenance training starts.

A summary of the report and its principal findings are presented in the final section.

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SHIPBOARD OBSERVATION OF ELECTRONICS PERSONNEL:  
IMPLICATIONS FOR THE TRAINING OF ELECTRONICS PERSONNEL.

I. INTRODUCTION

An extensive series of observations aboard ships of the destroyer class was directed toward a complete description of the shipboard electronics maintenance situation. A general description of this observational effort is presented in the first report of this series, and the observational techniques are detailed in the second report. The purpose of the present report is to examine the data, thus obtained, for the implications it may have for the electronics training program.

In addition to this discussion a second source of information is available to the reader. A complete summary of all data is presented as a classified supplement to Report No. 2 of this series. Interested readers may appeal directly to the data for answers to many specific questions which will not be dealt with here.

In the organization of a training program in a technical area such as electronics it is very important to have detailed information about the actual job which the men do after their training period is completed. Conversations with Navy training personnel have suggested that it is very difficult to acquire such "feed-back" to the training schools from the fleet. In an effort to overcome this lack of "feed-back" some training people have requested their graduates to write a letter or return a questionnaire offering suggestions for the improvement of the training program. Unfortunately, they found this voluntary program to yield a very low percentage of returns, and

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many of the responses were vague.

The present research should provide accurate and detailed information regarding the shipboard activities of the electronics technicians and the present conditions aboard ships of the destroyer class. This information should provide a bridge between the training program and shipboard activities and make possible a determination of their relationship.

The remainder of this report will be organized around issues involved in training. The order in which the discussions occur is entirely arbitrary. They are based mainly upon the training of electronics technicians but many of the points will be pertinent to the other subgroups and to training in general.

## II. SHIPBOARD TRAINING

Instructors at training schools contend that they can provide only the essential elements of the ET's training. Further development of a man's potential must be attained aboard ship. If this is the case, what is it that the ETs lack at the time they leave school? What is the nature of the additional training that they receive?

All of the ETs and most of the officers were asked to suggest what was needed to complete the training of the ET who came to the ship directly from Class A school (General Questionnaire, item 2<sup>1</sup>). The consensus of opinion was that the ET needed considerable practical experience after the conclusion of his Class A training. If this is the case, what method should be

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<sup>1</sup>  
Throughout this report parenthetical references indicate the specific source of the information referred to in the text. These sources are discussed in detail in Report No. 2 of this series.

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used aboard ship to overcome this lack of practical experience?

The ETs, the electronics materiel officers, the OIC officers, the ASW officers, the communications officers, the department heads, and the executive officers were asked to rank the following alternatives in terms of their effectiveness as methods for shipboard training (General Questionnaire, item 30):

- a. Organized training in which someone acting as a teacher prepares and schedules lessons on various gears and then teaches groups or classes.
- b. Informal individual training of the type one just "picks up" while repairing equipment.
- c. Individual tutoring in which a man who knows the gear takes the new man "under his wing" and trains him.
- d. Unscheduled sessions in which someone who knows the various gear tells the man about it in an informal fashion.

Table 1

Opinions Concerning the Types of Training That Would Be Most Effective For a Man Just Out of Class A Electronics School: Expressed in Terms of the Median of the Ranks Assigned by the Members of a Respondent Group.

(General Questionnaire - Item 30)

Respondent Group		Median Ranks Assigned To:			
		Organized Group Training	Informal Individual Training	Individual Tutoring	Unscheduled Training Sessions
69	ET	2.8	3.4	1.2	2.6
12	ENO	3.0	3.5	1.2	2.8
13	OIC	3.0	2.8	1.0	3.1
10	ASW	2.5	3.1	1.1	3.0
13	COMM	3.0	3.6	1.0	2.7
11	OPER	2.4	3.7	1.1	3.0
13	GUN	2.4	3.6	1.1	2.9
12	ENG	2.2	3.5	1.5	3.0
11	ENOC	2.1	3.3	1.3	3.4

Note.—Most effective type of training was given the rank of 1 while the least effective was ranked 4.

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There was unanimous agreement among the respondents that individual tutoring was the best method of shipboard training under these circumstances. Organized group training and unscheduled training sessions were considered to be moderately effective while informal individual training was considered by most of the groups to be least effective. Let us consider each of these types of training.

Informal Individual Training

The proponents of this type of instruction feel that a man will pick up considerable skill and information simply by being aboard ship and having intimate contact with the equipment. No formal efforts are made to teach the man in the usual sense---on the contrary, this sort of training is thought to proceed best when the man is left alone and allowed to explore the equipment. Members of the general questionnaire sample indicated that this is the poorest of the four alternative types shown in the questionnaire (see Table 1). Apparently, neither the electronics technicians, their supervisors, nor most of the supervisors of the operating personnel feel that this is a good method for shipboard training.

Additional information which can be brought to bear upon the problem of the man teaching himself can be obtained from the card sort method. In one portion of this method the men were required to indicate where they had learned the various maintenance activities which were part of their present jobs. They did this by placing cards bearing the job-activity statements into four categories. One of these was entitled "learned to do by self-instruction." The results of this sorting procedure are given in Table 2. This category is thought to include the "informal shipboard training" alternative of item 30 of the General Questionnaire. cursory inspection

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of Table 2 reveals that more cards have been placed in the "self-instruction" category than would have been expected on the basis of the opinions expressed on the General Questionnaire.

Table 2

Activities Learned By Self-Instruction				
Item		Number of ETs placing item in category	Frequency Index	Comprehension Index
180a	Repair headphones and headset	31	3.66	76
228	Obtain information from operators on how gear broke down	25	3.58	---
79	Repair phone cable	24	3.53	57
8	Lubricate bearings	23	3.33	44
229a	Check spare parts bins	23	3.49	37
140	Lubricate gears	22	3.14	45
274	Take inventory of ordinary hand tools	21	2.81	36
275a	Repair modulation and keying circuit in microphone	21	3.06	92
272	Take inventory of all spare parts	18	2.78	48
273	Take inventory of all portable testing equipment	17	2.79	41
137a	Replace broken interlocks	14	2.48	51
162	Mechanically adjust scope focus coil	14	2.79	87
183	Supervise corrective maintenance activities	14	3.81	117
102	Lubricate shaft couplings	13	2.91	41
74	Instruct ETs in maintenance fine points	12	3.78	136
104	Replace helipot assembly	11	2.25	103
45	Check antenna for binding	10	2.61	59
185b	Replace blower fans in electronic gear	9	2.12	60
99	Repair chipped paint on electronics gear, such as panels, doors, etc.	8	2.92	40
47a	Clean duplexer with solvents	7	2.31	66
72	Repair cooling system fans and lines in electronic gear	7	1.92	72
			2.97	65.4

Note 1.--- The bases for the interpretation of the Index Numbers are given in the following paragraph of the text.

Note 2.--- A detailed discussion of the procedures followed in selecting the items, determining the average frequencies and the Comprehension Index is contained in the Appendix.

\*This item was removed for administrative reasons.

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The number of electronics technicians placing each item in this category is given in column I. Column II consists of index numbers which indicate the frequency with which these tasks are performed aboard ship. Column III contains index numbers for the comprehension sort. At the bottom of the columns the average indices of frequency and comprehension are presented to facilitate a comparison of these activities with those given in other tables. For the entire card sort deck of activities, the frequency numbers range from 1.00 to 4.72 with an average of 2.57, and the comprehension numbers range from 34 to 138 with a median of 95.16 and a mean of 99.5. Results for the skill sort were very similar to those obtained for the comprehension sort.

2  
Twenty-one items met the criteria<sup>2</sup> for selection as representatives of the class "learned by self-instruction." They were performed with about average frequency and required considerably less than average comprehension. A close inspection of the content of the items reveals why this is the case. Five of the items (180a, 79, 275a, 99, 72) refer to low level repairs. A second group of items (229a, 274, 272, 273) were concerned with inventory activities. There were three replacement items (137a, 104, 185b) and three lubrication items (5, 140, 102). Three of the items placed in this sorting slot involved personal interaction with other shipboard personnel (228, 183, 74). The remaining items (162, 45, 47a) resembled the lubrication items in that they are related to preventive maintenance.

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See Appendix A.

Those items which were learned aboard ship by means of self-instruction<sup>3</sup> consisted largely of activities which were not a part of the man's responsibility during the time that he was in training school, but were a part of his shipboard responsibility. As a result, he may not have had any opportunity to perform these activities prior to the time that he was assigned to his ship.

For example, the student ET may learn about handsets while attending Class A school and he may be required to disassemble and inspect such sets. However, if a handset becomes inoperative during the time that he is using it in the school laboratory, he will exchange it for a functional one. Later, when the man is assigned to a destroyer, he finds that the upkeep and repair of handsets is a definite part of his own responsibility. As a result, although he may be very familiar with handsets and their construction at the time that he is assigned to his ship, he will not have been required to actually repair a handset until then. If this is the case, he is able to make this repair without additional training. It is possible to interpret all of the other activities listed in Table 2 in the same manner.

#### Unscheduled Training Sessions

During the planning stages of the present research, some officers indicated that an alert supervisor might frequently take advantage of unexpected

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<sup>3</sup> When interpreting these results it is helpful to keep in mind the fact that the ETs were instructed to adhere to a performance criterion, i.e., they did not include a card in a category unless they had performed it for the first time at the place indicated. Pretesting revealed the need for some definite criterion, and the performance criterion appeared to be the most satisfactory of those tried out.

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opportunities to conduct unscheduled informal training sessions. For example, he might capitalize upon an argument which had grown out of a bull session to present an organized discussion of pertinent points of information. He might obtain the use of some training aids without advance notice and collect the group on the spur of the moment for discussion. A man who had just returned from Class O school might conduct a brief informal session relating the highlights of his training to the rest of the group. This sort of training was the fourth alternative presented in the General Questionnaire item 30. Generally speaking, the respondent group considered this form of shipboard training to be slightly superior to informal individual training but inferior to individual tutoring and organized group training.

The "where learned" sort did not contain a category which was comparable to the unscheduled training session alternative presented in the general questionnaire. As a result, it is not possible to state the items which might have been assigned under this condition. However, in the course of the observations several instances of what appeared to be highly productive technical group discussions were encountered. An obvious weakness of this method of shipboard training is the realization that the leader of the discussion is not necessarily well prepared and the neophyte might well pick up incomplete or erroneous information. The method does not present itself as a type of training that can be relied upon as a dependable source of additional information for electronics personnel.

Organized Group Shipboard Training

In spite of the relatively high ranking of group instruction as a means of shipboard training of electronics personnel, available evidence indicates that it occurs infrequently. An examination of the logs, diaries, and interviews indicates that during the course of the observations made on twenty

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ships of the destroyer class (each observation period ranged from two to five days with an average of four days) no single instance of organized group training of ETs occurred. The observational methodology did not permit detailed eye-witness accounts of the activities of the sonarmen, radarmen, radiomen, and fire-control men; but conversations with the officers and men left the observers with the impression that, with the exception of the sonarmen, very few attempts were made toward group training in electronic maintenance aboard ship.

In anticipation of this situation, a question was included in the General Questionnaire which requested that any of six alternatives believed to be serious drawbacks to such training be checked (General Questionnaire, item 32).

Table 3

Opinions Concerning Drawbacks to Group Shipboard Training Expressed in Terms of the Number of Members in a Respondent Group Selecting a Given Response\* (General Questionnaire, item 32).

Drawbacks to Group Shipboard Training								
Respondent Group		No Room for Group Training	No Competent Teacher	People Too Busy for Group Training	Informal Non-Group Training Better	All Men Cannot Meet at One Time	Differing Apts. of Knowledge	Total
N	Design.							
71	BT	23	11	26	17	36	31	4
12	ENCO	--	3	5	4	3	5	1
15	OIC	2	2	6	1	6	4	2
14	ASW	2	2	2	3	2	2	6
13	COASH	4	4	8	1	4	4	1
13	CFER	--	1	9	--	3	2	3
18	GUN	6	2	6	2	7	4	6
12	ENG	3	1	6	--	3	4	2
11	EXEC	3	--	3	1	2	4	2

\*More than one selection was permitted.

\*\*NR = No Response

On the basis of these results, the alternatives may be ranked in the following order with the most serious drawback at the top of the list and

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the least serious at the bottom:

- a. People are too busy to take time off for group training.
- b. All men can never get together at one time for training.
- c. The men have such different amounts of knowledge that group training always wastes somebody's time.
- d. There is no room for group training.
- e. Informal, non-group training is better.
- f. There is no one competent to act as a teacher.

It is interesting to note that, although lack of space is often given as a reason for infrequent shipboard group training, the above table indicates that available time and differing amounts of knowledge are more important factors. The fact that the small complement of ETs is divided into watches when the ship is operating throughout a twenty-four hour period tends to discourage group training in maintenance because it is difficult to get all of the men together at the same time. These results are generally applicable to the various operating personnel as well as to the electronics technicians.

An analysis of the results of card sortings by electronics technicians substantiates the observational data that group training is seldom employed on board ship. Few of the ETs placed any cards in slot 2 (learned by formal shipboard training). A very small percentage of the activities stated on the cards of the card sort (there were 247 activities in all) were first learned as a result of group classes conducted aboard ship.

On the basis of these observations, group training cannot be depended upon to serve as a means for providing the necessary shipboard training of electronics personnel.

Individual Tutoring

Another method for training a new man aboard ship is to assign him to a more experienced man who is expected to take the new man "under his wing" and teach him particulars of the job. Frequent references were made in the observational data to the fact that each particular piece of gear has unique properties. It may be that its circuitry is a little different from others or, more frequently, that its malfunction forms a pattern. The man who has been aboard the ship for some time has learned to recognize these facts, and can pass this information on to the new man at the same time that he checks him out on the equipment. These job particulars are one type of information transferred to the new man during individual tutoring or buddy-training.

It is possible to list many additional attributes which contribute to the recognition of this type of shipboard training as being the best one of the four alternative methods rated by the general questionnaire sample, (see Table 1). Generally speaking, however, it is the close, personal guidance which the new man receives while working on maintenance problems he had not previously encountered except on a theoretical level. This method of training, i.e., being under the supervision of an individual tutor is one of the most effective means of supplementing shore training and filling what is reported to be the greatest need in the development of an  $\text{ET}^2$ 's potential--practical experience.

Data obtained by the card sort method also bears upon this issue. Although buddy-training was not specified as a category in the card sorting procedure, the items that were learned as a result of individual tutoring were customarily placed in the slot labelled, "Learned to do in informal shipboard training, etc." The results of this sorting are presented in Table 4.

Table 4

Items Learned by Informal Shipboard Training				
Item		No. putting items into category	Frequency Index*	Comprehension Index*
51	Requisition spare parts	33	4.14	51
143	Replace cathode ray tube	31	2.54	57
182	Fill out failure report	31	4.21	64
142	Replace lighthouse tubes	29	3.41	69
220	Mag antenna lines	29	3.63	57
4	Replace magnetron tubes	28	2.72	94
117a	Determine power output of communications transmitter	23	3.86	99
65	Check crystals	22	3.26	86
222	Keep file of stock tally cards	20	3.85	44
27a	Manually tune cavity resonator	18	3.03	102
217	Make monthly report of operation and performance of certain electronic equipment	18	3.79	79
237a	Determine front to back ratio of crystals	18	2.97	91
144	Replace klystron	17	2.57	104
221	Correct instruction books when field change is made	17	2.85	55
33a	Replace electronically operating keying relays	16	2.33	97
66	Replace quartz crystals in the crystal unit	15	3.32	83
240	Synchronize PFI sweeps in corrective maintenance	13	2.62	100
223	Submit field change report card	12	2.95	58
25a	Adjust unblanking voltage	11	2.81	102
252	Check for current loop with neon glow tube or voltmeter	10	3.17	87
39	Install coaxial cables	9	2.35	81
163	Fill out installation record	9	2.60	64
54	Replace T/R box	7	2.00	102
111	Repair leaks on transmission lines	7	2.00	84
135a	Measure signal to noise ratio by using scope	7	2.62	114
216b	Check frequency spectrum of magnetron	7	3.15	128
256	Tune and adjust fathometer	7	2.90	106
			3.02	84.74

Note 1.—A detailed discussion of the procedures followed in selecting the items, determining the average frequencies and the Comprehension Index is contained in the Appendix.

\*See page 6 for description of indices.

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Table 4 is prepared with the same format as Table 2. The average frequency of the twenty-seven items indicates that these activities are engaged in as often as those referred to in the previous table. However, these items require considerably more electronics comprehension than those learned by self-instruction.

The selected items fall into some rather definite groups. Seven of the items (143, 142, 4, 144, 33a, 66, 84) deal with the replacement of various parts of electronic equipment. These replacements generally require difficult and different techniques as compared with the usual tube replacement. Many ETs experience difficulty in replacing magnetrons without breaking the tips. The chief difficulty involved with the replacement on CRTs is the precision necessary in the mechanical positioning of the tube. (In this connection, it is of interest to note that several technicians commented that they felt that they had received somewhat better training in purely electronic matters than in those tasks which require mechanical ability.) One would expect that the student ET would have had little opportunity to replace such tubes prior to his assignment because these tubes are all expensive, fragile, and relatively long lasting. These activities are so complex that they require the individual supervision of an experienced technician during initial attempts at replacement.

Seven other items (51, 152, 222, 217, 221, 223, 167) are concerned with record keeping and paper work in general. It is important to note that this group of seven represents all of the items of this nature that were included in the original deck. It is significant that all of these items fell into this sorting category. The inescapable conclusion is that the ET fresh from school has a great deal to learn aboard ship about paper work. A common complaint among the technicians was that they had not received adequate training

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in such things as record keeping. When they were assigned to a ship they found themselves confronted with a great deal of paper work which had to be kept in a precise manner, but which they were relatively incapable of handling. Those ETs who had received at least some orientation in these more or less administrative matters while at school confessed that they were not appreciative of the importance of correct administrative techniques at the time they were taught. In this regard the underway training teams provide a great deal of assistance to the newly activated crews and many of the electronics records reflected their influence.

It must be stated, however, that in many cases the records are either not kept, or they are poorly kept, and most technicians seem to have a feeling that they are keeping the records for someone else. Perhaps the shore school could make its contribution in this area by stressing the fact that paper work such as reports and stock controls are of immediate importance to the man himself as well as the Bureau.

A third set of seven items that were learned by informal individual training (220, 117a, 65, 237a, 252, 135a, 216b) involve measurement and the use of test equipment. Items (27a, 240, 26a, 256) involve fine coordinated motor adjustments. The final two items (111, 39) are related to transmission lines.

The activities which were learned as a result of informal shipboard training were rated as requiring a fairly high degree of electronics comprehension and they were performed with at least average frequency. This suggests that these topics may be sufficiently important to warrant more emphasis in the shore school training program.

On the basis of Tables 2 and 4, it appears that some of the tasks which had not been performed at shore school but which are necessary for

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the shipboard job require relatively little comprehension and consequently can be easily picked up without assistance. On the other hand, certain of these tasks are sufficiently high level to require the assistance of other members of the ET gang in order for the new ET to achieve proficiency.

### III. SHORE SCHOOL TRAINING

One of the divisions of the "where learned" sort was labelled, "Learned<sup>4</sup> to do at Navy shore school." The items placed in this class are detailed below. This list should not be construed as exhaustive of those things learned at shore school, and it is not intended to provide a basis for an evaluation of the schools themselves.

All of the present research was done aboard ship and no effort was made to investigate present shore school training curricula. The job statements employed in the card sort method were collected from general electronics textbooks, various training manuals, and manufacturers' instruction books. The impracticality of including every observable maintenance activity of an electronics technician is obvious.

However, the available information is presented in the interest of completeness and in the hope that the relative position of the items within the list would assist the training school personnel to determine which items deserve more emphasis.

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<sup>4</sup>

See Appendix A for criteria used in selection.

Table 5

Items Learned at Shore School				
Item		No. putting items in category	Frequency Index	Comprehension Index
151a	Trace circuit continuity by means of schematic	53	4.43	113
232a	Use shorting bar	53	4.13	59
145	Read schematic diagrams	51	4.72	116
147	Use volt meter	51	4.61	76
90	Tune TDE manually	47	3.87	96
186a	Measure tube transconductance with tube tester	46	4.61	71
178	Determine value of component from color coding	44	4.32	61
152a	Check for open coil	42	3.35	83
161	Replace rectifier tubes	41	3.82	60
155	Measure transformer voltage	39	3.37	75
169	Vary tank circuit capacitance with variable capacitor	39	3.87	81
159a	Replace fixed resistor	36	3.53	69
226	Visually inspect tubes for open filament	36	4.29	64
146	Observe waveforms with portable scope	34	3.19	110
157a	Replace fixed fuses	34	4.06	42
158a	Replace fixed capacitors	34	3.44	68
278	Measure transformer resistance	34	3.15	69
225	Visually inspect tubes for gas	33	4.18	72
25	Adjust antenna coupling	32	3.76	96
32	Replace potentiometers	32	3.18	32
175a	Test vacuum tube for intermittent shorts by rocking it in tube tester	28	4.49	63
148	Trace signal by means of scope	27	3.20	114
168a	Vary tank circuit inductance by screwdriver adjustment	27	2.83	96
87	Tune IF stages	26	2.75	109
203	Measure tube current	26	3.32	88
115	Align superheterodyne receiver	25	2.73	119
172	Measure receiver performance with signal generator	23	2.79	115
59a	Check tube for gaseous breakdown by meter	22	4.00	82

Continued on next page.

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Table 5  
(Continued)

188	Draw schematic diagram	22	3.26	121
5	Replace coils	21	2.53	85
97	Measure relative power with echo box	19	3.56	98
54a	Measure capacity of capacitor	17	2.91	83
86	Tune local oscillator frequency by adjusting repeller voltage	17	3.58	107
170	Compute voltage requirements in a given circuit	17	2.84	124
233a	Check the grounding of electronics equipment by using voltmeter	16	3.54	74
63	Measure output frequency of radio transmitter	15	3.67	99
215a	Measure oscillator frequency in radio equipment using signal generator	15	3.08	106
1	Replace variable capacitors	14	2.33	82
128	Measure AVU voltage	14	2.92	92
211	Use HF signal monitor to determine transmitter frequency	14	3.64	98
153a	Trace signal by means of vacuum tube voltmeter	13	3.35	114
196	Measure oscillator output	12	3.18	107
132	Measure input signal strength	11	2.83	102
204	Measure current in resonant circuits	11	3.50	99
171	Compute current requirements in a given circuit	10	2.62	124
122a	Compute resonant frequencies in tank circuit	9	2.30	126
130a	Measure selectivity (band pass) of communications receiver	9	2.50	125
35a	Neutralize or balance power of amplifier stage by neutralizing capacitor	8	2.36	121
67	Measure decibels of power	8	3.00	109
71	Match impedance of transmission line	8	2.86	118
75	Measure percentage modulation using an oscilloscope	7	<del>2.32</del> 3.37	<del>122</del> 92.96

Note 1.—A detailed discussion of the procedures followed in selecting the items, determining the average frequencies and the Comprehension Index is contained in the Appendix.

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Fifty-one items met the criteria for selection as representatives of Navy Shore School learning. The frequency with which these were performed was considerably above average. As for comprehension and skill, these activities were rated by ETs as being slightly below average. The items group themselves into four major types: measurement, the use of schematics, the computation of circuit requirements, and the tuning and adjustment of the equipment.

This list consists of approximately one-quarter of all the items in the original deck of activities. Although the group of activities shown does not include every maintenance activity of the ET, it represents many of them in a general way. These activities, which were learned and first performed at shore school, seem to encompass almost all phases of maintenance except two extremes, the lower one of actually removing and replacing a particular part or component and the upper extreme of integrating the knowledge gained by these activities into a diagnosis of equipment malfunction. The question of practical experience might refer to either extreme. From other observational data it appears that this is the case. References are made throughout the data to a definite need for more experience in removing and replacing parts. Suggestions are also made throughout the data for more time to be spent during training in trouble-shooting as an integrated activity in addition to the present method of studying the isolated elements of trouble-shooting.

In summary, one may say that the ET learns most of the tasks that he performs aboard ship while he is in attendance at a shore school. This training is supplemented by a number of relatively low level activities which are first performed aboard ship but probably could have been done at an earlier stage in the technician's training. Items of this type were generally

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learned by reading textbooks, manuals, and other forms of self-instruction. Higher level activities were indicated as having been learned with the assistance of other ETs. Formal, organized, shipboard training classes in electronic maintenance are virtually non-existent and contribute little to the training of electronics technicians.

With regard to shipboard training most people recognize the fact that an ET stands to learn something every time he attempts to repair a piece of equipment, and the radarmen learn about their equipment as a by-product of CIC problems. The sonarman operates and repairs his equipment and learns something new about it or develops some new procedures for working with it. The principal difficulties involved in this casual training for electronics maintenance are: (1) an unduly long time is required to develop mastery of the equipment, (2) the supervisors may rely on it exclusively and fail to develop adequate training programs aboard ship, and (3) some subject matter requires instruction, it cannot be picked up.

With regard to the time element, relatively rapid turnover of electronics personnel at the present time does not permit a leisurely mastery of the gear. Both the equipment and the personnel are continuously changing and it is unlikely that a sufficient supply of adequately trained maintenance personnel would accrue from such a time-consuming training program.

A second shortcoming is closely related to the attitude of the supervisors, a key factor in shipboard training. Many of the supervisors participating in the present study felt little responsibility for the training of the men they supervised. They felt that the men should have been trained before being assigned to the ship, and should require only brief orientation with the gear in order to achieve an acceptable degree of proficiency. Other

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recognized the need for electronic maintenance training but had been "too busy" to develop an adequate training program.

It was mentioned above that some subject matter requires instruction which cannot readily be picked up. This fact is often overlooked, although it should be obvious. Many tasks particularly those involving manipulative skills are extremely difficult to learn from textbooks and almost necessarily must be learned on the job. The learning of these is quite appropriate for apprentice type shipboard training.

There are many additional complicating features with respect to the shipboard training situation. One of the major factors is that many ships are operating below their proper complement. It was not unusual to find an ET/3 acting as the leading petty officer for his group. No one, including the man himself, felt that he had the necessary knowledge and experience to effectively accomplish his assignment. Under these circumstances, the very process of keeping the gear operating required all of the acting lead's time leaving none to devote to any type of training program.

In light of the need for systematic shipboard training and the fact that individual training was rated so highly in comparison with other methods it may be fruitful at this point to consider at least one form such training could take. The more experienced man of each group (or the man most familiar with a given piece of equipment, as the case might be) could supervise a less experienced man during his first attempt at a new type of repair or while working on unfamiliar equipment. In many cases, the experienced man could carefully demonstrate techniques and present the theory underlying the operation of the gear. It seems likely that a new man could be teamed up with a man working on one type of gear for a while and then team up with another man working on another type. Some of the "in-between rates" might teach a

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seaman part of their time, and serve as junior members on a team with the leading petty officer at other times. This arrangement would also permit the training of the lower rated petty officers in some of the non-technical leading petty officer responsibilities. Perhaps the principal hindrance to such a program is that the full cooperation of the men has not been secured, and they have not been sold on the value of such a procedure. A logical first step would be to inculcate the leading petty officer with his responsibility for the training of the men that he supervises.

It should be emphasized that the simple pairing up of MEs would not result in the electronics training of the less experienced man. It may turn out that the inexperienced man would become a flunky for the more experienced man and spend most of his time doing menial routine tasks which require little skill and provide no opportunity for training. Later in this report, the problem of "specialization" at menial levels will be discussed in somewhat greater detail.

The importance of ME attitudes and the attitudes of their supervisors, with relation to shipboard training are additional problems which will be discussed in a later section.

#### IV. CURRICULUM CONTENT

The man on the job is in a good position to evaluate the subject matter of his own training. He has had an opportunity to put it to work and form opinions as to those topics which are most useful to him.

These opinions, when combined with those of naval training personnel, and other informed persons form a basis for the development of school curricula tailored to shipboard jobs.

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In an effort to determine the opinions of the men on the job, a training questionnaire was devised and distributed to the ETs. This was made up of 45 non-performance items similar to topics presented in electronics textbooks and 66 performance items adapted from conventional electronics laboratory exercises. The ETs were asked to consider each item carefully and to indicate its position along a job proficiency dimension. The dimension was composed of five categories ranging from "of no value to job proficiency" to "absolutely essential to job proficiency."<sup>5</sup>

The questionnaire items were presented in random order except that the performance items were all grouped together. In the process of analysis, median values were calculated to represent the rating given to each item by the group. The appropriate median is shown in parentheses following the item. The medians with lowest numerical values indicate the items judged most essential to job proficiency. These values and a measure of variability of the judgments for each item are given in the Supplement of Report No. 2 of this series. For the convenience of the reader, clusters of related items will be discussed below and the value to job proficiency of each item is indicated by Roman numerals. The symbol (I) indicates the items rated highest by the group, (III) indicates items rated lowest, with (II) indicating the items rated in between. It is undoubtedly wiser to evaluate these responses on this relative basis rather than the absolute basis of the scale itself. Since no median judgment fell below the scale category labelled, "of moderate value to job proficiency" there is reason to suspect that all

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For details, see pages 53 to 57 of Report No. 2 of this series

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ratings were displaced toward the high end of the scale. In any case, the use of a relative basis does not require assumptions regarding the absolute scale in the interpretation of the results.

In each group of items presented below, those judged to be of most value to job proficiency are presented at the top of the list with subsequent items arranged in order of decreasing importance.

Non-Performance Items

Group A. Twenty-seven non-performance items were related to electrical concepts. These concepts are generally taught early in electronics training courses. They are very general and usually regarded as fundamental to the understanding of electrical circuits. The electronics technicians rated them in the following manner:

**I**

Principles of current flow. (1.23)  
Concept of resistance. (1.26)  
Principles of capacitance. (1.47)  
Theory of impedance. (1.60)  
Principles of inductance. (1.65)  
Kirchoff's laws. (1.67)  
Nature of inductive reactance. (1.82)  
Nature of capacitive reactance. (1.93)  
Concept of phase. (1.94)  
Characteristics of the sine wave. (1.97)

**II**

Properties of electrical conductors and insulators. (2.02)  
Principles of electromotive force. (2.03)  
Units of electrical force, work, and power. (2.16)  
Time constants. (2.27)  
Principles of static electricity. (2.53)  
Structure of capacitors. (2.79)  
Concept of Q. (2.80)  
Concept of power factor. (2.81)  
Distributive capacitance. (2.84)  
Distributed inductance. (2.85)  
Properties of electro-magnets. (2.93)

**III**

Structure of inductors. (3.02)  
Properties of permanent magnets. (3.14)  
The atomic nature of electricity. (3.17)

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III(Continued)

The right hand rule. (3.23)

Vector analysis of L, C, and R circuits. (3.23)

Magnetic reluctance. (3.29)

Group B. In addition to basic electrical concepts, the trainee is taught the essential features of electrical circuits. Four of the more basic electrical circuits were included as items in the training questionnaire and they were all rated in the highest category as indicated below:

I

Essential features of D.C. and A.C. circuits. (1.22)

Characteristics of series-resonant circuits. (1.43)

Characteristics of series LC circuits. (1.51)

Characteristics of parallel-resonant circuits. (1.93)

Group C. Discussion of electrical circuits may serve as an introduction to meters, their uses and circuitry. The electronics technicians rated training questionnaire items of this type in the following manner:

I

Uses of voltmeter, ammeter, and ohmmeter. (1.09)

II

Circuit analysis of cathode ray oscilloscope. (2.40)

Moving-coil principle. (2.59)

Details of the construction of ammeters, voltmeters, ohmmeters. (2.62)

III

Principles of watt meters. (3.13)

Moving vane or plunger principle applied to meters. (3.56)

Group D. Eight items from the training questionnaire were of the type that are usually discussed as an introduction to radio and radar systems.

These items were rated in terms of their value to the ETs' shipboard proficiency. These ratings are listed here:

I

Principles of receivers. (1.14)

Theory of operation of various radar sets. (1.52)

Types and uses of detectors. (1.63)

Concept of carrier waves. (1.66)

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I (Continued)

The concept of band width. (1.85)  
Methods of obtaining modulation. (1.96)

II

Theory of operation of radar countermeasures. (2.78)  
Concept of the ionosphere. (2.93)

Group E. A great deal of the electronics technicians Class A training is devoted to the study of electron tubes. The following items concerned with tubes were rated with respect to the jobs of ETs as performed aboard ship:

I

Uses of vacuum tubes. (1.24)  
Theory of electron emission. (1.43)  
Theory of operation of gas tubes. (1.94)  
Amplification factor of vacuum tubes. (1.95)

II

Theory of operation of cathode ray tubes. (2.02)  
Transconductance of vacuum tubes. (2.05)  
Interpretation of characteristic curves of vacuum tubes. (2.20)  
Theory of operation of V-I tubes. (2.27)  
Interelectrode capacitance of vacuum tubes. (2.29)  
Theory of operation of beam power tubes. (2.33)  
Internal plate resistance of vacuum tubes. (2.35)  
Structure of vacuum tubes. (2.49)  
Theory of operation of light-house tubes. (2.53)

III

Theory of the phanotron. (3.34)  
Theory of operation of photo tubes. (3.62)  
Theory of operation of electric eye tubes. (3.63)

Group F. Items which were specific to amplifiers were rated in the following manner:

I

Theory of Class A amplifiers. (1.40)  
The theory of Class C amplifiers. (1.47)  
The uses of IF amplifiers. (1.56)  
Theory of operation of R-C coupled amplifiers. (1.60)  
The theory of Class B amplifiers. (1.62)  
The uses of video amplifiers. (1.75)  
The uses of R-F amplifiers. (1.77)  
Theory of operation of push-pull amplifiers. (1.81)  
The uses of audio-amplifiers. (1.82)  
Factors of distortion in amplification. (1.98)

II

Theory of operation of transformer type amplifiers. (2.02)  
Theory of operation of direct coupled amplifiers. (2.17)  
Theory of overdriven amplifiers. (2.21)

III

(No items were placed in this category).

Group G. Some of the training questionnaire items pertained to sources of electricity or electrical power. The opinions of the ETs with regard to these items are summarized in the following list:

I

Sources of trouble in power supply. (1.42)  
Theory of rectifiers. (1.59)  
Types of power supply circuits. (1.74)  
Applications of rectifiers. (1.84)  
Crystals as a source of electricity. (1.88)

II

Sources of D.C. voltages. (2.06)  
Types of rectifiers. (2.10)  
Basic motor and generator principles. (2.19)  
Magnets as a source of electricity. (2.38)  
Structure and operation principles of various generator types. (2.68)  
Uses of batteries. (2.88)

III

Theory of batteries. (3.07)  
Thermo-electric sources of electricity. (3.26)  
Methods of care of batteries. (3.62)

Group H. Topics related to transformers, synchros, and filters are grouped together because of a common property—all of the items are concerned with modifying voltage networks.

I

Uses of transformers. (1.79)  
Theory of operation of transformers. (1.86)  
Principles of electrical filters. (1.86)  
Uses of synchro-systems. (1.86)  
Synchro principles. (1.97)  
Types of voltage regulator circuits. (1.98)  
Uses of voltage regulators. (1.98)  
Characteristics of transformers. (1.99)

II

(No items were placed in this category.)

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III

Relationship between current and voltage in star transformer connections. (3.02)

Structure of transformers. (3.06)

Relationship between current and voltage in delta transformer connections. (3.30)

Group I. Six non-performance items were concerned with the structure and theory of electronic sub-assemblies. The shipboard electronics technicians placed them in the following order of importance to job proficiency:

I

Types and uses of radar scopes. (1.64)

Uses of relays. (1.93)

II

Structure and operation of relays. (2.35)

Theory of operation of a transducer. (2.57)

Structure and operation of circuit breakers. (2.61)

Structure and operation of starting boxes. (2.89)

III

(No items were placed in this category).

Group J. The items related to transmission lines and antennas in the non-performance section of the training questionnaire were rated as follows:

I

Theory of impedance matching. (1.78)

Theory of coaxial transmission lines. (1.95)

Theory of transmission lines. (1.96)

II

Types and uses of radar antennas. (2.09)

The relative advantages of various types of transmission lines. (2.41)

Skin effect. (2.77)

III

The theory of modes of wave guides. (3.21)

The concept of 'E' and 'H' lines of force in wave guides. (3.63)

The concept of phase velocity of wave guides. (3.73)

Group K. Many of the special circuits contained in navy electronic equipment are emphasized in training. These circuits were rated by ETs aboard destroyers and the results of their ratings are presented below:

I

Theory of the cathode follower. (1.85)

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II

Types of AVC circuits. (2.11)  
Theory of the differentiating circuit. (2.19)  
Theory of the limiting circuit. (2.29)  
Principles of regenerative and degenerative feedback. (2.35)  
The theory of the tuned-grid tuned-plate. (2.40)  
Theory of the phase inverter. (2.40)  
Theory of discriminator circuits. (2.42)  
Theory of neutralization. (2.53)  
Theory of clamping circuits. (2.65)

III

(No items were placed in this category).

Group L. The items in the training questionnaire pertaining to various types of oscillators are grouped below:

I

The theory of crystal oscillators. (1.61)  
Theory of the multi-vibrator. (1.69)  
The theory of beat frequency audio oscillators. (1.80)  
Theory of the saw tooth generator. (1.90)

II

Theory of operation of Klystrons. (2.05)  
Theory of the blocking oscillator. (2.07)  
The theory of electron coupled oscillators. (2.07)  
The effects of parasitic oscillations. (2.15)  
The theory of the Colpitts oscillator. (2.30)  
The theory of the Hartley oscillator. (2.33)  
Theory of frequency modulated UHF oscillator. (2.77)

III

The theory of the Armstrong oscillator. (3.36)  
The theory of the Wein bridge oscillator. (3.54)

Group M. Seven of the non-performance items of the training questionnaire fell outside of these classifications. They are presented below:

I

Discussion of color coding systems. (1.32)

II

Wave forms and harmonics. (2.02)  
Theory of sound. (2.82)

III

Types of headphones and speakers. (3.06)  
Concept of decibels. (3.27)  
Theory of the Doppler effect. (3.45)  
Units of mechanical force, work, and power. (3.92)

### Performance Items

The second section of the training questionnaire was composed of performance items similar to exercises usually included in laboratory programs. These items are presented in the same way as the non-performance items already shown on the preceding pages.

Group N. One group of items appear to be directly related to the understanding and trouble shooting of complete sets of electronic equipment. These items are definitely maintenance activities:

- I
  - Read schematic diagrams. (1.02)
  - Trace circuits of transmitters and receivers. (1.11)
  - Perform exercises in trouble shooting. (1.13)
  - Determine the function of various units within a circuit. (1.22)
  - Perform exercises in locating bad tubes. (1.23)
  - Trace signals inside receivers. (1.23)
  - Align a superheterodyne receiver. (1.26)
  - Perform exercises in locating bad resistors. (1.29)
  - Perform exercises in the use of front panel indicators for locating areas of trouble. (1.33)
  - Perform exercises in locating bad capacitor. (1.38)
  - Draw block diagrams of various radar equipment. (1.92)
- II
  - (No items placed in this category).
- III
  - Test circuit continuity. (3.63)

Group O. The remaining performance items were concerned with the measurement of dynamic properties of electrical circuits. They were:

- I
  - Measure current (amps.). (1.50)
- II
  - Measure power output of transmitters. (2.02)
  - Perform exercises with L-R frequency meter. (2.02)
  - Perform exercises in measuring pulse width. (2.57)
  - Measure A.C. impedance quantities. (2.61)
  - Perform exercises in measuring standing wave ratio. (2.89)
  - Determine power factor. (2.98)
- III
  - Plot tube characteristic curves. (3.26)

Group P. A number of the calculations that are required during the early training phase of an electronics technician's career were rated in an effort to determine their relevance to the shipboard job of the technician. These are presented in the following group:

I  
Calculate resistance, current, and voltage using Ohms law. (1.28)  
Calculate values in series circuits. (1.58)  
Calculate values in combined series-parallel circuits. (1.92)

II  
Calculate values in parallel circuits. (2.31)  
Compute inductance. (2.43)  
Calculate values of meter shunts. (2.56)  
Compute average power output of a radar set. (2.63)  
Compute capacitance. (2.68)  
Convert frequency to wave length. (2.71)  
Compute time for radar signal to reach target and return, knowing the distance it travels. (2.73)  
Calculate inductance of coils. (2.79)

III  
Compute root mean square voltages. (3.13)  
Compute the Q of cavity resonators. (3.38)  
Compute characteristic impedance of transmission line. (3.43)

Group Q. Some of the more elemental maintenance activities taught in electronics laboratory periods are listed below:

I  
Memorize color codes. (1.37)  
Perform exercises in soldering. (1.42)  
Practice making various preventive maintenance checks on transmitters. (1.71)  
Perform exercises in chassis wiring. (1.85)  
Perform exercises in taking wave forms. (1.86)

II  
Perform familiarization exercises on oscilloscope. (2.13)  
Calibrate oscillator. (2.14)  
Perform exercises in record keeping. (2.19)

III  
Perform exercises in cleaning equipment. (3.25)  
Phase out transformer. (3.31)

Group R. Several of the items included in the performance section of the questionnaire are associated with the tuning procedures and operator's

checks of equipment. These items follow:

I

Perform exercises in tuning various transmitters. (1.36)  
Determine direction of current flow. (1.41)  
Perform exercises in tuning in frequencies of radio receivers. (1.65)  
Perform exercises in taking ring time. (1.72)

II

Perform exercises in adjusting transmission line slugs. (2.27)  
Perform exercises in detecting and ranging on objects. (2.35)  
Plot selectivity curves of receivers. (2.62)  
Check for standing waves. (2.85)

III

Plot antenna radiation. (3.08)

Group S. The next group of activities involve the construction of electronic equipment as a means of training.

I

(No items were placed in this category).

II

Build a power supply. (2.20)  
Build amplifier. (2.30)  
Construct a two-stage receiver. (2.35)  
Build a multi-vibrator. (2.50)  
Build a saw-tooth generator. (2.50)  
Construct a simple transmitter. (2.58)  
Build a phase inverter. (2.73)  
Build a cathode follower. (2.74)  
Build a blocking oscillator. (2.79)  
Build a differentiating circuit. (2.79)  
Build a diode limiting circuit. (2.89)  
Build an audio oscillator. (2.93)

III

Construct a Wein bridge oscillator. (3.61)  
Construct A.C. meters. (3.68)

Close inspection permits the statement of a few general characteristics of the results. The two classes of items, performance and non-performance, were judged equally important to the job of the NF. The highest rated item of all, a performance item "read schematic diagrams" had a median rating of 1.02. The measure of variability for this item was the lowest of all items

(semi-interquartile range equals .26). Such a small value indicates a great deal of agreement among those rating the item and indicates that ETs uniformly hold the opinion that laboratory exercises requiring the reading of schematic diagrams are of great value when the ET later finds himself aboard ship and responsible for the care and upkeep of electronic equipment.

The second most important item was the non-performance item entitled, "uses of voltmeters, ammeters, and ohmmeters." The median and semi-interquartile range for this item were 1.09 and .30, respectively. These figures may be interpreted in the same manner as those given for the first item-- there was very close agreement among the ETs that the knowledge of how to use these meters was essential to successful performance of an ET's shipboard maintenance activities.

At the low end of the scale, we again find that the performance and the non-performance items are intermingled. The item rated least important to job proficiency was one of those presented in the non-performance section (Concept of phase velocity of wave guides). This item had a median of 3.73 and a semi-interquartile range (Q) of 1.04. The relatively large semi-interquartile range indicates wide divergence of opinion regarding this item as a training topic. Although most of the ETs placed the item in the lower three categories of the scale, a few considered the item to be of considerable importance for the shipboard job. This wide distribution of judgments may be indicative of item ambiguity or it may be a result of unfamiliarity with the concept. Under any circumstances, more confidence may be placed in those items having small dispersions as compared with those items having large dispersions.

The next to the last item in the list was a performance item (construct A.C. meters) with a median of 3.65 and a semi-interquartile range of .69.

When all of the items are ordered according to the magnitude of their medians, the intermingling of non-performance and performance items occurs throughout. On the basis of this it appears that laboratory exercises are judged to be equal in importance to classroom lecture topics by the electronics technicians. More direct evidence for this is the fact that the average median for each group of items is 2.29.

Another general characteristic of the results is the relatively low rating of items related to the construction of equipment. As a group, the ETs did not consider that these training activities contributed as much toward shipboard job proficiency as the performance items more directly related to trouble shooting.

Careful inspection of each of the groups of items presented above reveals the fact that those items assigned to the III category are generally not encountered in the daily performance of shipboard electronic maintenance while those placed in the top category (I) are more common. The sub-lists contain certain hints as to the appropriate level to which training should be carried in shore school. One such hint is contained in the list of electrical fundamentals. The reader will note that the concept of phase is included in the top group whereas the vector analysis of L, C, and R circuits is relegated to the bottom group of topics. On the basis of this it would appear that phase relationships are understood at a non-mathematical level and the more rigorous analytic techniques are not considered to be necessary for job proficiency.

There is a general tendency to place training topics related to "how to do it" above those topics which might be considered in the "why" category. For example, the uses of voltmeters, ammeters, and ohmmeters are rated higher than the details of their construction. Since the ET does not construct the

meters (although he is expected to be able to repair them), he is not particularly interested in construction details.

Certain general topics of training appear to be of less importance to the job than might be expected. The general topic of magnetism is rated toward the low end of the scale. Again, this may be related to the fact that the design of the equipment and the construction of the magnetic elements within the equipment is out of the EF's hands. The properties of permanent magnets and such concepts as "magnetic reluctance" are probably of more importance to the designer and manufacturer of such components than to the maintenance technician.

The list of items related to tubes demonstrates another fairly general characteristic of the total list in that the broadest topics are placed at the top of the list while specific items of information occur at the bottom. When the items range from such general topics as "uses of vacuum tubes" to specific items such as "theory of operation of electric eye tubes," this tendency to list the most general items at the top of the list is apparent.

Once again it appears that EFs tend to rate low those topics which are not part of their usual assigned maintenance duties. Such items as care and uses of batteries and principles of operation of various generators are rated below such items as sources of trouble in power supply and types of power supply circuits. One may surmise that power supply problems are of more immediate interest to the EF because he is responsible for the upkeep of the power supply section of various pieces of electronic equipment while the ship's electricians are depended upon to care for the various primary power sources. More direct evidence of the role of trouble shooting topics as related to the EF's job is given by the high rating of all of the trouble shooting performance items. With one exception, all of the items in this

group were placed in the top rating category. On the basis of this, it appears that laboratory exercises involving the development of trouble shooting proficiency and skill are very helpful to the man once he is assigned to a destroyer.

One final characteristic of this group of items deserves mention at this point. One of the more controversial areas in the construction of the curricula for ET training schools has been the extent to which certain calculations were necessary. Many have charged that the shipboard performance of the ET's duties does not require the use of these calculations and, therefore, they should not be included in the training unless they could be justified on other grounds. When all the computational items from the training questionnaire are listed together, we find that several are judged to be essential to performance on the job. Generally speaking, the items at the head of the list are concerned with the calculation of values for basic electrical circuits, while those at the end of the list are of greater importance to equipment design and advanced theoretical considerations than they are to practical applications. The shipboard observers reported few instances where paper and pencil calculations were employed during trouble shooting activities although most technicians gave evidence of continual concern for the general relationships present in Ohm's law. A technician would be seriously handicapped if he were not taught and made fully cognizant of such fundamental calculations as are presented at the head of the list but he could probably do his job without having been taught to compute such things as the Q of cavity resonators.

Before leaving the section on the training questionnaire, it may be well to briefly evaluate the technique as a device for determining which training topics should be included in a training curriculum and which of these should

be emphasized. As mentioned previously, there had been a feeling that the shipboard ETs represented an untapped source of good information regarding the value of established training programs. Certain efforts to obtain voluntary reports from school graduates have not been sufficiently productive of information. The present questionnaire was personally administered to a large group of technicians. This group was quite cooperative and for the most part sincerely tried to do a good job. Under these circumstances, the questionnaire technique was given a fair trial. The results, however, were disappointing. All ratings were grouped toward the high end of the scale and as a result only very general interpretations could be made. It is very likely that the ETs as a group are a potent source of the type of information desired about training program effectiveness. However, since the ETs are not trained as raters, new rating techniques must be developed in order to capitalize upon this source of information.

At the beginning of this section the reader was cautioned that the results from this questionnaire should not be accepted uncritically or in isolation. Certain implications of the results have been suggested and the persons immediately concerned with training problems will undoubtedly find still others. In many cases it may be that topics which are rated relatively low by the technician should be emphasized in training because these topics serve as necessary stepping stones in the development of a comprehensive understanding of other topics which are more immediately applicable to the shipboard maintenance situation.

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Two possible methods for overcoming the displacement of the ratings toward the high end of the scale are, 1) the use of forced distributions in some subsequent questionnaire technique, or 2) the use of a triad item of the sort employed in certain interest inventories.

## V. SPECIALIZATION

In this section of the report an attempt will be made to describe the kinds of specialization observed in the course of the research and to discuss their implications to training. A basic problem in the training of ETs is concerned with whether it is desirable to have a man trained to do a small number of things very well (a specialist in the usual sense) or whether it is better to train men who will be able to maintain and repair almost all of the electronic equipment aboard their ships.

Some have advocated the combination of the operation and maintenance of a given kind of gear under one job title. Under this arrangement a man would be responsible for both the operation and the maintenance of this equipment. The sonar team is presently organized in this way and observational data indicates that when a ship is properly staffed with a full complement of sonar-men, the equipment is kept in good shape and is operated at a satisfactory level of efficiency.

There are those who argue that the job of the radarman and the job of the electronics technician should be combined into a job comparable to that of a sonarman. They emphasize the fact that at least some of the present maintenance problems result from the operators lack of understanding and appreciation of the equipment which he handles. This would be obviated in a situation where an operator was well trained in maintenance because he would be careful to do nothing which would require his spending repair time and effort. Such training would keep him from damaging the gear through ignorance.

These same people also argue that this arrangement would be more efficient on the grounds that a maintenance man is unnecessary when the equipment is properly functioning and an operator is unnecessary when the equipment is broken

down. They point out that under the present situation the maintenance man spends his time waiting for the equipment to break down when it is operative or the operator waits for it to be repaired when it is inoperative.

These arguments are based upon the assumption that radar men do nothing other than operate the electronic equipment and that the electronics technicians have no responsibilities other than restoring to operation search radar which has become inoperative. Analysis of the observational data indicates that there is very little actual overlap between the jobs of the radar men and the electronics technicians, and therefore, very little basis for such a combination.

The selection and training of personnel for such diverse jobs would entail a reduction in the number of suitable recruits because the two types of responsibility would probably involve different sets of aptitudes and interests. Furthermore, training time would necessarily be lengthened because of the diversity of the jobs. In addition there would be the danger that the trainees themselves would consider one part of their duties as primary and the other part as secondary so that in the process of placement it would be impossible to know whether the man being assigned was primarily an operator or primarily a maintainer.

The members of the general questionnaire sample were practically unanimous in their agreement that the IE rating should not be combined with any of the operator ratings (General Questionnaire, item 16) and that the maintenance of the gear should be the primary responsibility of the technician whereas the operation should be left to the operator (General Questionnaire, item 1).

This leads one to ask how much maintenance the operator should do. What specific maintenance responsibilities should be assigned to them and which

should be denied them? What should be the limits on the operator's responsibility for the maintenance of the electronic equipment he uses? Several specific questions were included in the general questionnaire in an effort to determine the opinions of the groups involved in the general problem. Table 6 presents the responses to a question exploring one possible limit to the operator's responsibility.

Table 6

The Percentage of Individuals in Each of Various Respondent Groups Who Favor Allowing Operators to Do Maintenance on the Inside of Electronic Equipment. (General Questionnaire, item 2).

		OPERATORS											
Respondent Groups		NO			NR			NO			NO		
		%	%	%	%	%	%	%	%	%	%	%	%
#	Design.	Yes	No	NR	Yes	No	NR	Yes	No	NR	Yes	No	NR
21	ET	23	77	—	32	68	—	89	11	—	87	13	—
12	EMO	67	33	—	67	33	—	100	—	—	83	17	—
15	OIO	67	33	—	67	13	20	88	—	20	73	—	27
14	ASV	64	29	7	71	14	15	78	14	8	86	7	7
13	OCM.	54	23	—	85	15	—	77	—	23	69	—	31
13	OPR.	77	23	—	92	8	—	100	—	—	84	8	8
18	GUN.	17	28	55	22	22	56	33	17	50	83	11	6
12	ENG.	42	58	—	50	50	—	75	25	—	92	8	—
11	ECMO.	45	45	10	54	36	10	45	45	10	73	18	9

\*NR = No Response

With two exceptions, the majority of electronics technicians and officers participating in the research felt that operators should be permitted to do maintenance inside their equipment (General Questionnaire, item 2). The ETs felt that the radar and radio operators should not perform any maintenance activities on the inside of their equipment. At the same time, however, it was felt that operators should be trained in many of the routine tasks such as cleaning the gear, making minor adjustments, and certain preventive maintenance activities. In particular, it was felt that the operator should be

able to recognize malfunction of equipment so that ETs could be notified before the equipment failed completely.

Table 7 below indicates that it was also generally felt that the operator of a piece of equipment should do twice as much preventive maintenance on that equipment as the electronics technician (General Questionnaire, item 1). It is interesting to note the inference that operators should be trained beyond the minimum essentials for the operation of their equipment and prepared for the responsibility of preventive maintenance in addition to their primary task.

**Table 7**

**Opinions as to the Percentage of Preventive Maintenance ETs Should Do on Different Types of Equipment, Expressed in Terms of the Mean of the Percentages Assigned by Each Respondent Group. (General Questionnaire, item 1).**

Respondent Groups		% of Preventive Maintenance to be Done on:							
N	Design.	Radar by		Sonar by		Radio by		Fire Control by	
		ETs	RDs	ETs	SOs	ETs	RMAs	ETs	FOs
71	ET	33	67	14	86	34	66	24	76
12	MO	29	71	12*	88*	32	68	26*	74*
14	MO.	44	56	38	62	41	59	25	75
12	RMCO.	46	54	33	67	36	64	19	81
13	OPMR.	32	68	19	81	30	70	—	—
13	DIC	32	68	—	—	—	—	—	—
17	ASW	—	—	14	86	—	—	—	—
11	COMM.	—	—	—	—	37	64	—	—
10	SUN.	—	—	—	—	—	—	22	78

\*Mean percentage calculated from N-1 cases.

These opinions are generally substantiated throughout the observational data. Although neither the radar nor the radio operator participate in any planned shipboard maintenance training program, an informal type of training occurs in some instances. The technician who is working on a piece of gear makes an effort to familiarize the operators with the symptoms of the breakdown to enable the operators to recognize these symptoms more readily should

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they occur again.

General Questionnaire item 15 asked the opinion of shipboard personnel regarding the desirability of having one ET who is trained and works solely and specifically on preventive maintenance. The responses to this question are given in Table 8.

Table 8

Opinions as to Whether There Should be One ET Trained Solely for Preventive Maintenance; Expressed in Terms of the Percentage of a Respondent Group Selecting a Given Alternative. (General Questionnaire, item 15).

Respondent Group		ET for Preventive Maintenance		
#	Designation	% Yes	% No	% No Response
71	ET	6	94	—
12	IMO	—	100	—
15	OIO	33	67	—
14	AW	7	79	14
13	OCSL	8	84	8
12	OWR	31	54	15
18	OWR	11	67	22
12	IMO	8	92	—
11	IMO	18	73	9

The response was a resounding "no." The item had been incorporated in the questionnaire because it had been suggested on several occasions as a way of accomplishing the required amount of preventive maintenance. It is obvious that this suggested solution to that problem is regarded as generally unsatisfactory by the shipboard personnel.

There is one kind of specialization of ET function which is important to detect, as it occurs within the fleet, simply because it defeats the purpose of the general training given to the ETs in Class A school. This form of specialization is informal and unplanned. During the course of the fleet observations, one outstanding example was noted. In this case, an ET/3 did all of the paper work for the ET gang and never worked with any of the equip-

ment. In effect, this man was working as a specialized yeoman. All of the ETs and the electronics material officer aboard the ship were well pleased with the arrangement. This particular ET had a flare for record keeping and paper work in general and preferred to function in this capacity; the other ETs were pleased to be relieved from the routine paper work, and the electronics material officer liked the set-up because he was certain that the paper work was being kept up to date and would pass inspection at a moment's notice.

This single case was sufficiently successful to suggest that some consideration should be given to the idea of creating a yeoman's job which encompassed this activity. However, it is obvious that the expensive and extensive training of the technician which purportedly prepared him to maintain equipment was to a very large extent being wasted, and in the event of his transfer after a year of this highly restricted activity, one wonders how effectively he could assume the normal duties and responsibilities of an electronics technician.

In the opinion of the observers, if there is enough work of this sort to occupy the full time of a man then it may be wise to train a man for this work, to reduce the paper burden of the ETs, or to otherwise deal directly with this problem. But it is wasteful and unwise to allow this sort of informal, unplanned specialization of function to grow up.

Another example of this kind of specialization was noted. It develops because certain tasks are less interesting or more arduous than others. As a result, these tasks are assigned to the strikers and they tend to become specialized as menials. Under these circumstances, they have very little opportunity to learn about many aspects of the job. For example, a radioman striker may spend almost all of his time running messages and actually have

little opportunity to become better acquainted with the radio equipment or its operation. Since this enforced specialization in the menial aspects of the job falls to the lot of the lowest rated man in the group, a paradoxical situation results--the men who need the most additional training get the least. The obvious solution to this problem is to make sure that the routine, low-level duties are shared by all members of the group.

Reviewing all of the observational data it is apparent that various kinds of specialization occur to varying degrees. On the whole, specialization is considered an extremely poor and inefficient method of training. The observational data accumulated from the sample of destroyers under investigation contains no evidence which would warrant a modification of the training program in the direction of more specialization. The present program of training is considered by almost all of the naval personnel participating in this study as providing a foundation for the development of a man's potential.

It is a truism that it is quicker to teach a man a few things than to teach him many. Therefore, it may be necessary during conditions of emergency to introduce a great deal of specialization in the training program simply because there is not sufficient time to provide the kind of training necessary for the "jack-of-all-trades." However, the usefulness of highly specialized HTs who lack an adequate general background is open to question. There is a danger that they may become obsolete with the equipment that they were trained to service and such specialists present great problems of placement and shipboard administration. Consider the difficulties involved in seeing to it that every ship was staffed by exactly the right kinds of specialists under all circumstances. Consider also the fact that equipment aboard modern ships is so varied; there is not enough room for the large number of technicians who would be required to maintain the gear.

It must be realized, however, that this problem cannot be adequately dealt with at a theoretical level only. The eventual decision as to the kind of training to be given will always depend upon a complex of practical factors. It is not necessary to enumerate all of these but one readily recognizes the importance of such factors as the time allotted to training, the availability of suitable trainees, and circumstances under which training will be put to use.

#### VI. ATTITUDINAL PROBLEMS

Most of the people concerned with training recognize the fact that attitude and interest are key issues in the effectiveness of their programs. A sound program may not serve as a training medium at all if the attitude of the student toward it is negative and his interest is low. There is no doubt that all would agree to the complexities involved in any attempt to determine the attitudes or interests of the personnel selected for training in electronics. This research team made no direct effort to collect data on this point. However, in the course of the observational series, numerous occasions arose where these factors were discussed with electronics personnel.

There were instances where men with little interest in electronics had been selected because of the results of qualifying examinations. The attitude of these men was one of passive negativism. They were capable of completing their training to the satisfaction of all concerned but their attitude was reflected in a lack of pride in their work aboard ship and the acceptance of minimal responsibilities for the equipment. Their primary concern was to get away with doing as little as possible during their tour of duty. There is no doubt that this had an effect upon the other men.

Two alternatives present themselves as possible solutions to this type of problem. (1) if it can be determined that a man has no interest in electronics, he should not be selected as a trainee; (2) the fact that this type of attitude exists should be recognized at the very beginning of the training program and steps taken to modify the attitude and increase the interest.

On the other hand, many men enter service for the specific purpose of qualifying for electronics school and receiving the training that the service offers to them. They complete their course satisfactorily and eagerly await the opportunity to put their knowledge to work. However, once they have been assigned to a ship, months may elapse (in one case, close to nine months) before they actually are given an opportunity to work with the electronics equipment.

During this period of time, the highly trained electronics technician spends his time on all sorts of non-electronic duties such as mess cooking. A marked change in attitude occurs. He feels that his time is being wasted, that all of the effort he put into the training phase of his career was futile, and that the Navy has no intention of using his technical ability. His primary concern is to sweat out his time and separate himself from the navy as quickly as possible. Although the man's interest in the field of electronics may remain high, it is no longer associated with electronics equipment in the navy but restricted to a personal interest—the attainment of as much technical knowledge as possible for personal use after discharge.

One solution would entail putting the man who has just come aboard ship after completing training into immediate contact with equipment. Under strong petty officer leadership, the new ET can be made aware of the fact that his efforts are needed and that he is expected to assume and handle a degree of responsibility that is on a level commensurate with his recent schooling.

Thus, the "eagerness to get to work"--an attribute which is characteristic of most training school graduates--could be exploited for the benefit of the man himself as well as the service. The new ET's interest would remain high and a positive attitude would be more firmly established.

Most of the problems described so far have a "morale" flavor. There is one very important attitudinal problem, however, that is more closely related to the role that the ET assumes. There is a rather surprising amount of agreement among the ETs concerning the role of the ETs in the Navy. They tend to see themselves as skilled trouble-shooters and fixers. It is quite clear that they regard the best ET as being the one who can find and fix many different kinds of troubles on many different kinds of equipment. Everyone will agree that a really good ET should be able to do all of this finding and fixing--it is certainly one of the major functions of the job. However, it appears that this single aspect of the job, as important as it is, may have been overemphasized to the point that the technicians consider it to be the only important aspect.

This tendency for the ETs to regard themselves as "finders and fixers" tends to lead them to neglect other important duties that they should perform. The most important of these is the responsibility for keeping the equipment in peak condition and in a constant state of readiness. In order to meet this objective, the ET must constantly check out the equipment and must anticipate a breakdown and if at all possible prevent it. This kind of preventive maintenance does not occur on a ship that is staffed with a group of "fixers." As a result, it was not seen to occur on most of the ships of this sample. It is significant to note that there were some exceptions to this fixer attitude. When they occurred the man involved was inevitably a man with more than the usual time in the fleet and in every case

the electronic equipment on that ship functioned well.

The training schools can contribute a great deal toward the education of the ET who will appreciate all of the aspects of his job (corrective maintenance, preventive maintenance, supervision and training of personnel, record keeping, etc.). The schools are in a good position to actively foster attitudes which contribute materially toward a satisfactory maintenance program.

#### VII. REQUIREMENTS FOR TRAINING

As a result of informal conversations with a number of naval representatives during the planning stages of this research, efforts were made to obtain the opinions of selected shipboard personnel regarding possible changes in the requirements for admission to Navy schools. Item 17 of the General Questionnaire required the ranking of seven characteristics which had been suggested as important for ETs. (See Table 9).

All of the respondents (ETs as well as officers) agreed that the most important single characteristic for the ET to possess was a "high interest in electronics work." Many of the men who were asked to elaborate upon this response indicated that most ETs had the requisite abilities but many lacked the motivation required. The factor of interest is of particular importance to the technician aboard a ship of the destroyer class because he must be self-directed. The situation is such that the ET must take an interest in the equipment and its adequate upkeep to the extent that he will feel personally responsible and take pride in its continuous operation.

The factor of initiative was generally rated above the high OCT score although the difference between the ratings is not very great. In passing,

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Table 9

Median Ranks of Some of the Characteristics Which an Electronics Technician Should Possess,  
Obtained from the Rankings Assigned by the Individuals of Each of a Number of Respondent Groups,\*  
(General Questionnaire, item 17)

Characteristics											
Respondent Groups	I	Per- cent.	High GCF Score	Above Avg. Physical Coordination	High Interest in Electronics	Above Avg. Physical Stamina	Ability to Withstand Monotony	Pleasant Personality	Follows Direction Well	Hard Worker	Initiative
71			4.1	6.0	1.2	8.1	7.5	7.0	4.8	3.7	2.2
12			3.1	7.2	1.2	8.0	7.9	6.2	5.5	3.8	2.3
13			2.7	6.4	1.2	7.8	6.0	8.1	5.9	3.8	2.4
12			3.8	6.0	1.4	7.8	8.0	7.2	5.5	3.8	2.9
11			2.0	6.8	1.3	8.0	6.0	8.2	5.9	3.8	3.2
13			2.1	4.7	1.3	7.3	6.7	8.1	6.0	4.8	3.8
13			3.0	6.0	1.2	7.7	7.2	8.7	5.2	4.2	2.3
11			3.2	6.9	1.4	7.2	8.3	8.0	5.0	3.7	2.0
10			3.0	6.2	1.3	7.0	7.0	8.5	5.5	3.5	2.8

\*Most important characteristic was ranked 1; least important was ranked 9.

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it is interesting to note that there is a very common belief among shipboard personnel that the GOT score is virtually the only factor involved in the selection of recruits to be sent to Class A school.

At the other end of the rank order practically everyone agreed that factors such as 'physical stamina, ability to withstand monotony, and pleasant personality' were not so important as characteristics for the ET to possess.

Some people have suggested that the student's attitude during training would be more favorable if he had spent some time at sea prior to his training period. The argument is that the student who has only recently come from civilian life and who has never been aboard a ship at sea is unable to view his training in perspective and is not able to ask the intelligent questions that he could ask after a period at sea. The desirability of specifying that sea duty be a requirement for selection for Class A training was investigated by means of item 25 of the general questionnaire. The responses to this item are indicated in Table 10.

**Table 10**

**Opinions Concerning the Minimum Amount of Sea Duty a Man Should Have Before Attending Class A Electronics School; Expressed in Terms of the Percentage of Each Respondent Group Selecting a Given Response. (General Questionnaire, item 25)**

Resp. Groups		% Stating					% Giving No Response
N	Design.	None	3 Mos.	6 Mos.	1 Yr.	2 Yrs.	
71	ET	44	17	32	4	—	3
12	ETCO	50	25	25	—	—	—
15	OTC	20	20	27	13	—	20
14	ASW	21	7	29	7	—	36
13	COMAL	15	8	38	23	8	8
13	OPTR.	8	8	30	54	—	—
18	GUN.	17	11	22	17	—	33
12	ENC.	25	—	50	25	—	—
11	ENCOC.	18	9	46	18	9	—

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It appears that there is a rather even split among technical personnel regarding the desirability of sea duty prior to Class A training. Forty-four per cent of the electronics technicians expressed the opinion that no sea duty should be required while the remainder felt that a year or less spent at sea would prove advantageous. Some of the latter who had received Class B training felt that a primary benefit of this was the opportunity to consult with the instructors with reference to definite problems that had been encountered during time at sea. They felt that similar benefits would accrue from sea duty in advance of Class A school. A few of the respondents suggested that the technical school students would take their work somewhat more seriously if they had observed the status and working conditions of the EF as compared with certain other enlisted ratings. The officers who were not charged primarily with the maintenance of the electronic equipment did not express clear cut preferences but many felt that at least some sea duty was desirable. All respondents who indicated that no sea duty should be required emphasized the fact that this period of sea duty added to the training period would leave very little time in an initial enlistment period during which the man could serve as a trained specialist.

This last point suggests that there would be some advantage to restricting the training to those who indicate that they are interested in a navy career, i. e., Regular Navy men. Item 26 of the General Questionnaire asks whether or not EF training should be restricted to Regular Navy men. The responses to that item are presented in Table 11.

Table 11

Opinions Concerning Whether EE Training Should Be Given Only to Regular Navy Men: Expressed in Terms of the Percentage of a Respondent Group Selecting a Given Alternative. (General Questionnaire, item 26)

Respondent Group		EE Training Only for Regular Navy Men		
N	Designation	% Yes	% No	% EE*
72	EE	30	67	3
12	NO	8	92	—
15	OIC	7	86	7
14	ASV	7	79	14
13	CCM.	23	77	—
13	CVE.	8	92	—
18	GM.	6	72	22
12	WFO.	17	83	—
11	WFO.	9	91	—

\*None Response

A glance at the table shows that there is a preponderance of agreement that the training should not be restricted to Regular Navy men. In any event, it seems that such a restriction would be unrealistic in that there is a greater demand for trained technicians than there is a supply of available Regular Navy personnel. In the interview which was employed by the observational team, the EEs' future plans were discussed and most of them indicated that they were planning to leave the service at the conclusion of their current enlistment. On these grounds it seems likely that the Navy must plan a maintenance program which can be carried out by men who serve for only one enlistment period.

At the time that the various observational methods were being developed, it was suggested that the bases for the selection of men for Class B school might be quite different than those used for the selection of men for Class A school.

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Table 12

Opinions Concerning Prerequisites for Class B Electronics Training: Expressed in Terms of the Percentage of a Respondent Group Selecting a Given Response

(General Questionnaire, item 20)

Prerequisites for Class B Electronics Training																			
Respondent Groups	Regular Navy		Lengthy Sea Duty		Lengthy Combat Experience		Strong Interest in Electronics		High Class A School Grades		Good Electronics Perform. Record		Good Petty Officer Qualities		High SAT Score		% Giving No Response		% Giving No Response
	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	M	L	Both
71 EE	4	20	1	20	-	24	42	-	-	11	37	-	1	4	1	6	14	15	-
72 IO	8	8	-	42	-	33	33	-	-	8	50	-	-	-	-	-	-	-	9
75 CIC	7	33	-	27	-	13	39	-	7	-	27	-	-	7	-	-	-	-	20
74 ASN	-	21	-	29	-	29	29	-	-	-	30	-	-	-	-	-	-	-	21
73 COM.	8	8	-	15	-	54	23	-	8	-	23	-	8	8	15	-	8	-	15
75 OPER.	-	-	-	23	-	31	31	-	-	8	31	-	-	8	8	-	-	8	22
76 GUN.	-	6	-	28	-	34	22	-	11	-	33	-	-	-	6	-	-	-	28
72 ENG.	-	33	-	25	-	8	42	-	-	-	50	-	-	-	-	-	-	9	8
71 MEC.	-	36	-	9	-	27	9	-	-	-	64	-	-	9	27	9	-	10	-

\*N represents the percentage of a respondent group designating the prerequisite as most important, and L represents the percentage designating the prerequisite as least important.

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As a result General Questionnaire item 20 was included to determine important prerequisites for selection of men for Class B electronics training. The question required the respondent to indicate which of a list of eight suggested prerequisites was the "most important" selection factor and which was "least important." The responses to the question are presented in Table 72.

There is general agreement among all respondents that the regular navy requirement be omitted from consideration as a selection factor for Class B school. The reader will recall the same general agreement to disregard the regular navy requirement as Class A school selection factor. In addition, such prerequisites as "lengthy sea duty" and "lengthy combat experience" were also considered by practically all of the personnel completing the questionnaire to be of very small importance as selective factors for Class B school. On the other hand, a "strong interest in electronics" and a "good electronics performance record" were considered by all of the respondents to be very important in the selection of MEs for Class B training.

Informal conversations with the technicians during the course of the observations disclosed that MEs evaluate Class B training quite highly. Such education offers interesting possibilities as an incentive for reenlistment although not all MEs would be willing to extend their period of service in order to attend Class B schools.

#### VIII. DESCRIPTION OF PRE-NAVY TRAINING OF THE ME SAMPLE

Some of the biographical information collected during the investigation is directly related to training. Examination of this information reveals that the median number of school years completed for the enlisted personnel in the sample is 12, or generally that of a high school graduate. Most of

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those men who had not progressed beyond the high school level had majored in such courses as mathematics, science, industrial arts, and general academic work. The high school training of the ETs was the same as that of the other rates in the sample. However, certain differences were noticeable among the ETs who had gone on to college and the other rates in the sample. The most pertinent of these differences is the fact that the ETs college training was predominantly in the realm of engineering, whereas the other rates tended toward such major subjects as general academic, science, business, and education.

The members of the sample group were asked to indicate any civilian trade school training that they had received prior to their entry into the navy. One ET and two ETs reported that they had had some trade school training in electronics. A few others indicated training in electricity. Generally speaking, only a very small number of the electronics personnel had received any civilian training in the electronics field.

Half of the fire control technicians in our sample, one-third of the electronics technicians, and one-third of the sonarmen indicated that they had had some hobby interest in radio, general electronics, or electricity. Very few radio or radar operators indicated that they had hobbies related to this area.

An analysis of the civilian jobs held by members of the sample indicated that very few had held any job related to electronics. Farming, general clerical, general industrial, and mechanical trades were among those civilian jobs listed most frequently.

The implications of this information for training are straightforward. The electronics training program within the navy must be geared to handle high school graduates who have had little or no previous exposure to the

field of electronics.

## IX. SUMMARY

An extensive series of observations aboard ships of the destroyer class was directed toward a complete description of the shipboard electronics maintenance situation. The resulting data were examined for implications to the navy's electronics training program. The principal findings are presented below:

1. The electronics technician just out of Class A school is most in need of practical electronics experience.
2. Four alternative procedures which could be used aboard ship to further the training of electronics personnel were ranked. Individual tutoring was considered to be the best method for supplementing shore school training. Informal individual training was considered to be the least effective method of shipboard training. Organized group training and unscheduled training sessions were of intermediate value as shipboard training procedures.
3. An analysis of the card sort reveals that the EF learns most of his shipboard tasks at shore school and supplements his training with relatively low-level tasks learned from manuals and other forms of self-instruction. In addition, he learns certain higher level activities from the other EFs. Formal, organized shipboard training classes in electronics maintenance are virtually non-existent and do not contribute appreciably to the training of electronics technicians.
4. A discussion of the development of more effective shipboard training programs in the area of electronics maintenance indicated that lack

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of time and scheduling problems are considered principal obstacles to its development. Despite these impediments, the observers felt that more training in electronic maintenance could be accomplished if the electronics supervisors were sold on a shipboard training program and if they were assisted in the development of an adequate procedure for its implementation.

5. An attempt was made to determine the importance of selected curriculum topics in terms of the EEs job proficiency. The general features of these ratings were as follows: Topics discussed in school lectures were judged to be as important to the job as those topics explored by way of laboratory exercise. Topics related to the construction of equipment were rated low. These items rated at the lower end of the scale were of the type not usually encountered in the daily performance of electronics maintenance aboard ship. There was a general tendency to place training topics related to "how to do it" above those which might be considered in the "why" category.
6. Brief examination of the observational data yields no basis for radical changes in the job structure of those jobs related to the maintenance of electronic equipment and therefore no radical changes in the training program.
7. The electronics situation aboard ships of the destroyer class requires that EEs receive rather broad general backgrounds in electronics of the sort they are currently receiving.
8. The possibility of developing highly specialized EEs who could perform only certain of the present EE functions or maintain only certain pieces of equipment is explored. Shipboard personnel react unfavorably to such suggestions.

9. The influence of certain attitudes upon the effectiveness of training is noted. Recruits involuntarily assigned to electronics school give no evidence to indicate that they develop the necessary high interest in electronics in the course of their naval service. On the other hand, those emerging from Class A school with an eagerness to go to work are sometimes frustrated by being assigned menial shipboard tasks for an unduly long period of time. Specific mention is made of the importance of the EE's impression of his role in the electronics situation. The observation is offered that present EEs tend to emphasize their role as "finders-fixers" to the detriment of other important aspects of the job. It is suggested that the training schools could contribute to the improvement of the shipboard electronics situation if more attention was given to these attitudinal topics in addition to the customary technical topics.
10. When the shipboard sample was polled regarding the requirements for admission to navy schools, they indicated that "high interest in electronics" should be one of the most highly weighted factors in the determination of who should be sent to school. There was general agreement that training should not be limited to regular navy men and there was a rather definite feeling that potential EEs would profit from a three to six month tour of duty aboard a ship at sea prior to their formal Class A training.
11. The requirements for the selection of men to be sent to Class B school roughly paralleled those indicated with reference to Class A school.
12. An examination of the biographical information reveals that most

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of the electronics personnel have no special civilian background for their navy jobs. This is interpreted to mean that the naval electronics training program should begin at and be geared to the level of the high school graduate.

**X. FINAL NOTE**

Under normal conditions the training program is continually being reviewed and revised to keep pace with changing conditions. This report is not intended to present or to support any single point of view with regard to Navy training. In most cases, the eventual decision as to whether or not changes should be made in the training program (and if they are made, which direction they should take) will depend upon many factors beyond the scope of the present investigation. Such decisions must be made by those who are cognizant of all of the complex considerations which are not available to the writers. It is hoped that the information presented here will be of some assistance to those who are charged with these decisions.

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**APPENDIX**

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Appendix A

Method of Selection of Items for Tables 2, 4, 5

The items selected for Tables 2, 4, and 5, are based upon the results of sorting plan C of the card sort method. This is the sorting plan which asks the MT to place each card into one of four categories--each category being a place where the item was first learned:

<u>Slot</u>	<u>Where Learned</u>
1	Navy Shore School
2	Formal shipboard training
3	Informal shipboard training
4	Self-instruction

Two criteria were used in selecting the items listed in the tables indicated above.

First, no item was interpreted if less than 10% of the group selected it as an activity which best described his job. Therefore, no item was considered unless the frequency of placement within one of the four categories was seven or greater. (The total number of MTs participating in the card sort was sixty-six.)

Second, it was desirable to limit the discussion to those items which were unquestionably members of the given sorting category. Therefore, the major category frequency had to be greater than the sum of the frequencies within the other three categories.

Appendix B

Method of Determining Frequency Indices

Shown in Tables 2, 4, 5

Plan D of the card sort method required the RTs to assign all of the activities which they considered descriptive of their job along a "frequency of performance" dimension which contained five categories. One end of the dimension was labelled, "very rarely done" while the other end was entitled, "very often or most frequently done." Each of the five categories was then assigned consecutive weights from 1 to 5, the least frequent (or very rarely done) being assigned a weight of 1 and the most frequent, a weight of 5.

The number of times an item was placed in a category was multiplied by the assigned weight of that category.

The products for all five categories were summed and divided by the total number of placements in all categories. Thus, if all RTs had stated that a particular activity was "very often or most frequently done" the resulting numerical designation would be 5.

Appendix C

Method of Determining Index Numbers

Shown in Tables 2, 4, 5

The Comprehension and Skill sorts of the card sort method required the EIs to categorize the activities which best described their jobs.

Five categories were established for both the comprehension and skill dimensions. For the comprehension sort, the dimension extended from a lower end labelled, "very little electronics knowledge or understanding involved; practically nothing to "grasp" or "comprehend" here," to the upper end of the dimension entitled, "very much electronics understanding involved. Thorough knowledge is an absolute necessity in understanding the job." For the skill sort, the low end of the dimension was called, "very little or no skill required to perform the job; almost anybody could do it at the first trial," while the other extreme read, "very much skill required; the job required the highest degree of skill that the technician ever has to execute."

Consecutive weights ranging from 1 through 5 were assigned to each of the categories. The number of times an item was placed within a category was multiplied by the assigned weight of that category. The products for the five categories were summed and this total called the index number. These index numbers express the relative degree of electronic comprehension or skill involved with each of the items. The larger the index number, the more of the variable is involved.

Care should be exercised in attempting to interpret differences between index numbers.